# SILOSCAPE—A Novel Constant Force Escapement

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*With its combined expertise in micro-manufacturing techniques and precision mechanisms, CSEM has been a pioneer in the design and production of centimeter scale silicon parts featuring fine mechanical functions comprising flexures (FlexMEMS), opening up new opportunities for the design and production of novel and innovative watch mechanisms. In the frame of SILOSCAPE MIPs, CSEM is focusing on the design and production of novel high-performance watch oscillators and escapements. This year CSEM presents a novel constant force escapement based on the FlexMEMS design approach.*

Mechanical watch parts are known to be tiny, delicate and very precisely machined; this is particularly true for the constitutive parts at the very heart of any watch mechanism, namely the escapement and the oscillator. Towards the end of the 20th century, CSEM has been a world precursor in the use of silicon microfabrication techniques [1] for the design and production of very precise and thermally compensated Silicon watch hairsprings (the most critical part of the oscillator); doing so, CSEM paved the way to a new trend in the watch industry: the use of silicon as a base material for the design and production of mechanical watch parts . Since then, CSEM has kept on carrying its pioneering role by pushing further the frontiers of the micromechanical structuration of silicon [2] and by improving its expertise in the design and production of novel watch mechanisms based on this approach [3]. Building upon its extensive background and experience in the design of precision mechanisms guided by flexure blades in lieu of classical bearings, CSEM has proposed a novel approach combining the advantages provided by the precise micro-structuration of silicon to those of flexure bearings for the design and production of novel high-end oscillators and escapements. The so-called "FlexMEMS approach" is particularly useful when lubrication is prohibited due to the environment (eg: vacuum, space) or due to contamination restrictions (fine optics).

For the past 15 years CSEM has proposed several original designs of mechanical watch oscillators [4] and, in a close partnership with Vaucher Manufacture Fleurier, integrated at the watch level, the very first FlexMEMS Genequand escapement [5], the first flexure-based watch regulator (escapement + oscillator) ever designed and implemented at the watch scale. Since then, CSEM has proposed the Siloscape escapement [6] a novel FlexMEMS escapement: featuring a power reserve three times better than a conventional system and a classical precision performance, it is auto-starting by nature, which means that a large accidental shock cannot stop it.

The so-called Double Hammer escapement is the latest FlexMEMS based escapement designed and produced by CSEM (Figures 1 and 2). This innovative escapement is a constant force escapement which is targeting a very precise time keeping (typically +/-2 s/d) with a regular power reserve. Two silicon parts pivoted on flexure blades and called "hammers", are successively (at each alternance) armed by the escapement wheel which rotates them at a prescribed angle. It is storing a prescribed amount of energy in their flexure pivot, before releasing them so that the potential energy stored in their flexures is provided to maintain the oscillations of a Wittrick type FlexMEMS oscillator. Since, in the operating range, the potential energy stored in the hammers is constant and independent from the torque available at the escapement wheel, the oscillator will receive the same impulse energy at each alternance, keeping its amplitude as constant as possible during operation and therefore improving the time keeping precision of the watch.

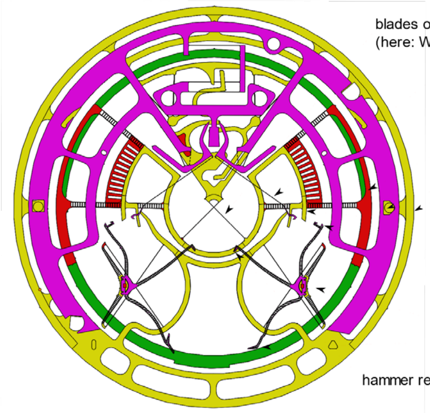


*Figure 1: Main constitutive parts of the "Double Hammer".*

The equivalents of the classical anchor impulse pallets are directly integrated on the oscillator which is produced as a monolithic silicon part assembled wafer-level. A second monolithic silicon part, comprising the two hammers and optional flex-guided hooks, is manually assembled to the oscillator. The flex-guided hooks are used to keep the hammer from touching the oscillator during the resting phase, minimizing the perturbations. With the "Double Hammer" and the Siloscape escapements, CSEM addresses two complementary market segments: high power reserve and chronometric performances.

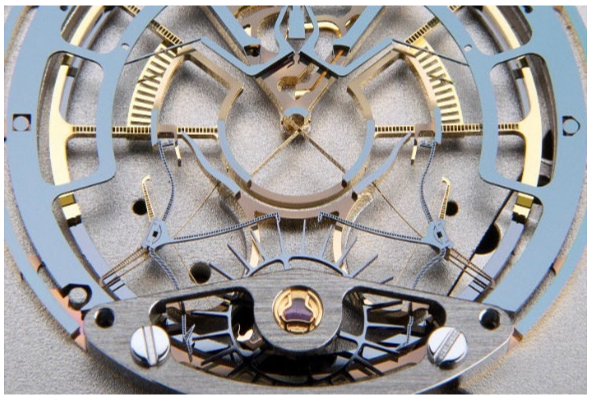

*Figure 2: The "Double Hammer" escapement integrated in a watch.*

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[3] M. Despont, *et al*., "Tic-Tac" made in Silicon", SSC, 2019.

[4] F. Barrot, *et al*., "Flexure based oscillators for mechanical watches CSEM Scientific and Technical Report (2018) 19.

[5] F. Barrot, *et al*., "Un nouveau régulateur mécanique pour une réserve de marche exceptionnelle", SSC, 2014.

[6] F. Barrot, *et al*., "A Novel Silicon-based Flextech Watch Escapement", CSEM Scientific and Technical Report (2019) 20.